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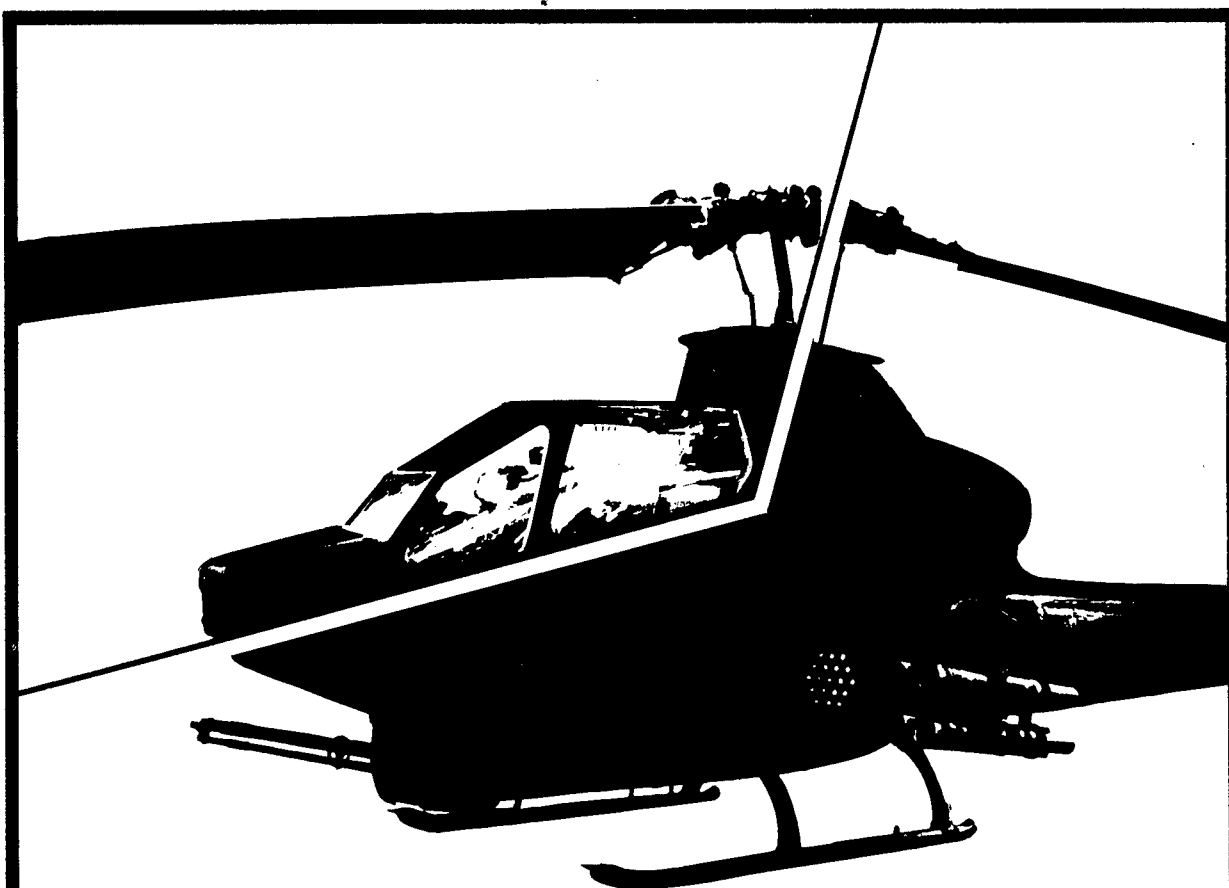
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THE ECONOMIC BENEFITS OF IN-FLIGHT ESCAPE SYSTEMS IN CURRENT AND FUTURE ATTACK HELICOPTERS

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TR 78-1
MARCH 1978
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**THE ECONOMIC BENEFITS OF IN-FLIGHT ESCAPE SYSTEMS
IN CURRENT AND FUTURE ATTACK HELICOPTERS**

by
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) All Army AH-1 aircraft accidents which occurred during CY 71 through CY 76 are analyzed for in-flight emergencies that are compatible with in-flight escape systems. An in-flight emergency model which considers the in-flight escape system sequence is discussed. The benefits, in terms of injury avoidance and cost savings, of in-flight escape systems are estimated. The potential benefits of in-flight escape systems are projected over a 20-year operational life of the attack helicopter fleet. Recommendations are made based on these results.		

FOREWORD

Traditionally, rotary wing pilots' philosophy in an in-flight emergency is to get the helicopter on the ground as soon as possible. In recent years, the idea of an in-flight escape system for helicopters has been explored for both technical and operational feasibility. With the advent of new and more sophisticated helicopter weapons systems the idea of an in-flight escape system has received renewed interest. The idea of staying with the aircraft in all types of emergencies is now being questioned. The study described in this report evaluated a proposed Required Operational Capability for an in-flight escape system projected against a scenario based on 6 years of Army AH-1 aircraft accident data to project benefits resulting from the use of the system.

It is intended that the information contained in this report be used in cost and operational effectiveness analysis of any proposed in-flight escape system. Also, this report can be used in the development of performance requirements for helicopter in-flight escape systems.

SUMMARY

A study of all AH-1 accidents which occurred during calendar years 1971 through 1976 was performed. The purpose of the analysis was to determine the benefits of an in-flight escape system in current and future attack helicopters. Previous crash injury experience was studied to determine those injuries that could have been prevented through the use of an in-flight escape system.

For this study a model of an in-flight emergency in terms of the in-flight escape sequence was developed. This model was used to system-

atically analyze each in-flight emergency and to determine what benefits (injury prevention and cost savings) could be realized in each individual accident. These benefits were used to establish total savings to be expected over a 20-year operational life. It was concluded that the benefits gained from the crashworthiness of the YAH-64 do not overlap the injury prevention benefits of in-flight escape. In the 20-year operational life of the attack helicopter, the use of an in-flight escape system would result in a 15-percent reduction in injury cost.

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The Economic Benefits Of In-Flight Escape Systems In Current And Future Attack Helicopters

INTRODUCTION

The need for an in-flight escape system for an attack helicopter is generally recognized by pilots.¹ However, some objections to its implementation are based on cost effectiveness, weight penalties, anticipated infrequent use, and the general upgrading of the next family of helicopters in the area of crashworthiness. The "staying with the machine" school of thought appears to be enhanced by the overall improvements in the YAH-64, Advanced Attack Helicopter, and the UH-60, "Black Hawk."

A proposed Required Operational Capability (ROC) for "In-flight Escape System for Attack Helicopters" has been drafted by Aviation Research and Development Command (AVRADCOM) (Appendix A). As the result of a request from the Director of Research, Development and Engineering, AVRADCOM, the U.S. Army Agency for Aviation Safety (USAAVS) performed a study to establish the usefulness of an in-flight escape system for the attack helicopter fleet. Specifically, the purpose of the analysis was to determine the benefits of an in-flight escape system in current and future attack helicopters. As a result, crash injury experience was reviewed and analyzed to determine those injuries that could have been prevented through the use of the proposed in-flight escape system.

OBJECTIVES

The overall goal of the analysis was to establish expected losses due to injuries in aircraft accidents for attack helicopters (AH-1/YAH-64) equipped with and without an in-flight escape system. Injury losses were projected over a 20-year period of peacetime operation.

An in-flight escape system has benefits beyond economic effects. The benefits of injury prevention include operational readiness and morale which are difficult to quantify. These are not addressed in this study.

ASSUMPTIONS

The major assumptions were:

- a. An extraction-type escape system having the capabilities outlined in Appendix A is installed in all attack helicopters.
- b. AH-1 accident experience provides a reliable basis for predicting future losses.

METHODOLOGY

Candidate In-flight Escape Systems. In-flight escape systems in addition to that described by Appendix A were reviewed for potential benefits. Specifically, the following type systems were considered.

- Parachute—Essentially a manual system requiring the operator to perform the majority of

the escape cycle. The parachute itself is considered to be currently available standard military issue. However, it was also considered that incorporated in the escape sequence was an automatic rotor severance, crew canopy opening, and an unaided crew egress. The rotor severance and canopy opening were assumed to have a reliability equal to that required by Appendix A for like systems.

■ The "Yankee" system—Fully automatic system using an extraction system of occupant evacuation. Capabilities are as specified in Appendix A.

■ A capsular system—Ejects the occupant automatically in some form of capsule generally composed in part or whole of the cockpit.

■ An ejection system—Fully automatic "seat" type ejection system, similar to the OV-1 system.

The last three systems listed are generally similar with regard to actions required of the pilot to escape. These three are termed automatic systems in this study and are considered to have the same escape envelope and mechanical reliability as required by Appendix A.

The latter three systems were studied to determine the sensitivity of the results to variations in the design approach for an automatic system. The parachute was studied to cover the full spectrum of possible design approaches. The preliminary results indicated no significant difference among the benefits of the automatic systems. On the other hand, the manual system or parachute proved to be of no significant benefit. It could not be demonstrated that even one injury could have been avoided by use of the manual system. Based on these factors the only data presented in this study are for the extraction system.

Overall Approach. The basic data for this study were all aircraft accidents which occurred in U.S. Army AH-1 aircraft during calendar years 1971 through 1976. Only aircraft accidents, as defined by reference 2, were considered, i.e., combat losses were not included. A total of 141 AH-1 aircraft accidents were studied as summarized in table 1. USAAAVS computerized accident files provided the case numbers of all AH-1 accidents for this period. For purposes of this report, AH-1 accidents include all those accidents occurring to TH-1G, AH-1G, and AH-1Q aircraft during calendar years 1971 through 1976.

TABLE 1.—Army AH-1 Accidents, CY 1971-1976

Number of Accidents	141*
Number of Accidents Resulting in	
Occupant Injury	62
Number of Aircraft Flight Hours	684,804
Accident Rate (per 100,000 flight hours) . .	20.58
Number of Occupants	281
Number of Occupants Killed or Injured . .	109
	or 38.8 percent of total occupants

*Three additional aircraft accidents during CY 71-76 involved other type aircraft flying into stationary, secured, and unoccupied AH-1 aircraft. These were not considered AH-1 accidents within the context of this study and are not included in the analysis and findings herein.

The accidents comprising the data base were analyzed to determine the possible benefits of in-flight escape. The analysis sequence is depicted in figure 1. A case by case analysis was made of the "hard copy" of each mishap report. A preprinted analysis worksheet (Appendix B) was used to standardize the analysis of each case and to record the results. After all accidents were analyzed in this manner, the benefits of each candidate system were calculated based on injury and personnel cost savings.

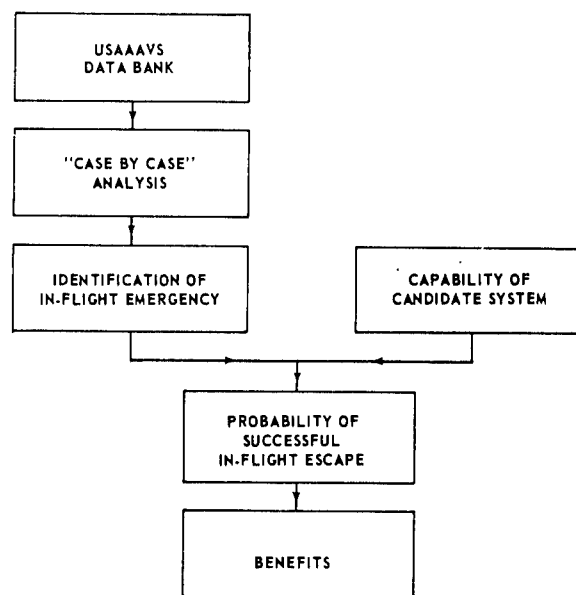


FIGURE 1.—Sequence of the Analysis of In-Flight Emergencies

Probability Analysis. The critical step in this procedure is determining the causes of the in-flight emergency and the possible utility of the candidate in-flight escape system in each case. To aid in this determination, a model of an

in-flight emergency was developed. This model is depicted in figure 2 in terms of the in-flight escape sequence. Details of the analysis procedure relative to the specific components of the in-flight emergency model are discussed below and are referenced to figure 2.

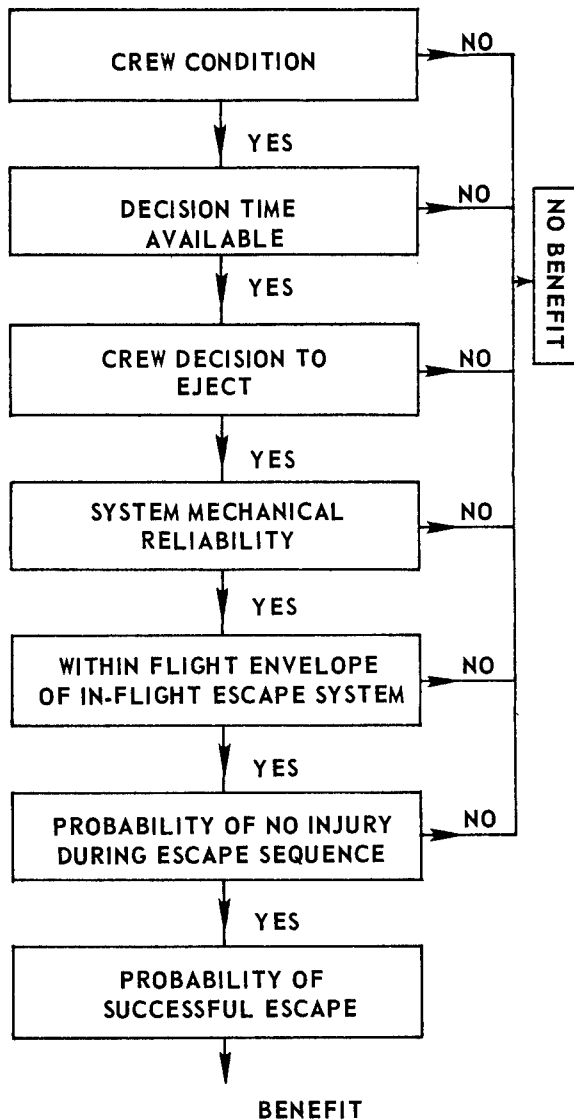


FIGURE 2.—Model of In-Flight Emergency

1. *Crew Condition*—Was the crew capable of initiating the escape sequence? This decision was based on such factors as physical condition, e.g., injuries.

2. *Decision Time Available*—Was there sufficient time to decide to use the system? This

decision was based on such factors as airspeed, altitude, and the type of actual in-flight emergency, e.g., fire, in-flight breakup.

3. *Crew Decision to Eject*—Based on the prevailing circumstances, what is the probability that the crew would choose to escape? Some of the factors involved are altitude, airspeed, terrain, and type of emergency.

4. *System Mechanical Reliability*—Given that the crew decides to escape, what is the probability of the escape system actuating properly under the circumstances surrounding the particular accident? The mechanical reliability of the system determines this factor.

5. *Within the Envelope of the In-flight Escape System*—Given that the crew decides to escape and the system actuates as designed, what is the probability that the escape sequence will be successfully completed before ground contact? The in-flight emergency was reviewed for compatibility with the escape envelope of the candidate system.

6. *Probability of No Injury During Escape Sequence*—Were there any additional factors which could have caused injury during escape and descent to the ground, e.g., fire, in-flight breakup, or hazardous terrain?

The model was used by answering the series of questions in the sequence shown. Each question was answered in terms of numerical probability of a "yes" answer. The process is sequential in that a "no" at any gate resulted in overall zero probability of success. The values assigned were the consensus of at least two analysts, each of whom individually studied the in-flight emergency and later combined findings. After the series of questions was considered for an in-flight emergency, the assigned probabilities were multiplied together to determine the probability of a successful escape. The multiplicative nature of the probabilities in this sequential model makes the results conservative, e.g., "bottom line."

Projected Accident Rate Analysis. Projected accident rates for both the AH-1 and YAH-64 were obtained from reference 3. The projected accident rate per 100,000 flying hours is 20.58 for the AH-1 and 10.2 for the YAH-64. These projections are based on a study of the same 141 accidents used in the present analysis.

Injury Prevention Analysis. Baseline number of injuries without in-flight escape for both the AH-1 and the YAH-64 were also obtained from the data of reference 3. Each of the 141 accidents was reviewed for injuries, both fatal and nonfatal. This analysis yielded 62 AH-1 accidents in which some degree of injury was sustained by the crew. Some of these injuries would be prevented in the YAH-64 by its increased level of crashworthiness. Each of these accidents was then reviewed for possible benefits of in-flight escape. The benefit of the in-flight escape system was computed by multiplying the probability of no injury (successful in-flight escape as computed by using the model of figure 2) by the number of fatal and nonfatal injuries sustained in each accident. The sum of these "saves" then resulted in the total number of injuries prevented by the in-flight escape system. This benefit was subtracted from the baseline⁴ to calculate the injuries in aircraft equipped with an in-flight escape system.

Estimated Cost Reductions Due to In-flight Escape. Baseline injury costs for the AH-1 were obtained as shown in table 2. The economic benefits of the in-flight escape system were computed by using the projected injury rate for aircraft with in-flight escape and the average injury cost from table 2. These projected losses were subtracted from baseline losses. This was used to calculate the projected benefit of the in-flight escape system for the period CY 71-76.

TABLE 2.—Cost of AH-1 Injuries,* CY 71-76

Type Injury	Number	Injury Rate/ Accident	Mean Cost Per Accident	6-Year Injury Cost
Nonfatal	70	.50	\$1.4K	\$2.2M
Fatal	39	.28	\$51.5K	\$7.3M
All	109	.77	\$53.0K	\$7.5M

*Based on reference 4.

Analysis of Crashworthiness vs. In-flight Escape Benefits.* The baseline YAH-64 injury data obtained from reference 3 takes into account the crashworthiness benefits of the YAH-64. In analyzing the further benefits of in-flight escape, each accident was reviewed to determine if crash-

worthiness eliminated an injury which also might have been eliminated by an in-flight escape system. In the case that crashworthiness did eliminate the injury, that injury "save" was not used in determining the in-flight escape benefits for the YAH-64.

RESULTS

Personnel Injury Cost and Rates for AH-1 and YAH-64 Helicopters. Figure 3 shows injuries sustained per accident for baseline attack helicopters compared to injuries forecast for attack helicopters equipped with in-flight escape systems under the same conditions.

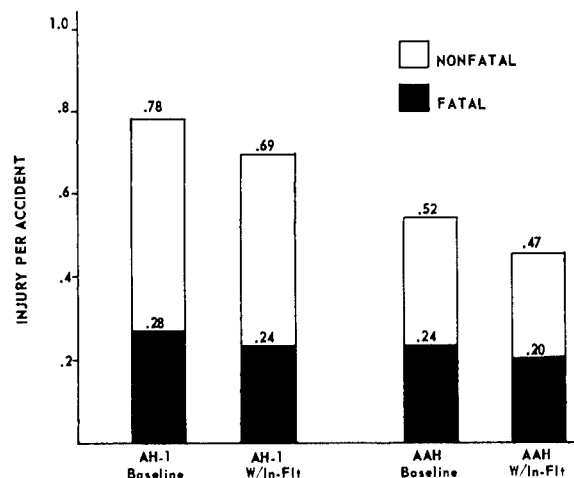


FIGURE 3.—Injury Rates Per Accident

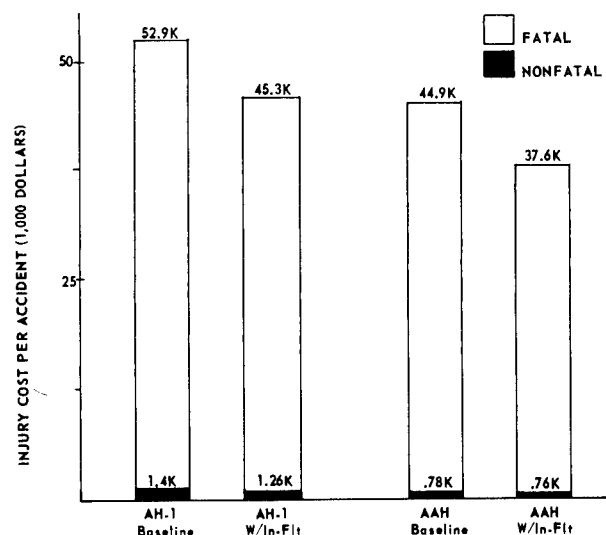


FIGURE 4.—Injury Cost Per Accident

*The Army in consort with the USN performed a feasibility demonstration of an in-flight escape system utilizing an AH-1 Cobra helicopter.⁵ This feasibility demonstration was conducted as a joint Army Navy effort. (See reference 6 in response to GAO Report (reference 7).)

Figure 4 shows the injury cost per accident for baseline attack helicopters compared to injuries forecast for attack helicopters equipped with in-flight escape systems under the same conditions.

Total Personnel Injury Cost for 20-Year Operational Life. Figure 5 shows the total personnel injury costs (fatal and nonfatal) from accidents over a 20-year period of a fleet of AH-1s and YAH-64s both with and without an in-flight escape system. The YAH-64 figures also reflect its improved flight safety and crashworthiness.

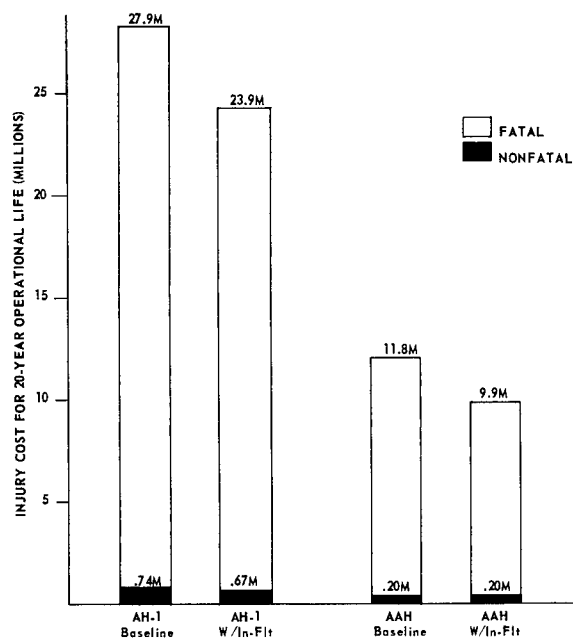


FIGURE 5.—Injury Cost for 20-Year Operational Life

The total personnel injury costs over the 20-year operation of the AH-1 and the YAH-64 are listed below:

	AH-1	YAH-64
Without in-flight	27.94M	11.8M
With in-flight	23.97M	9.90M
20-Year Economic Benefits	3.97M	1.90M
Percent Reduction	14.2	16.1

The estimated economic benefits of in-flight escape are about twice as great in the AH-1 as in the YAH-64 due largely to the projected lower accident rate of the YAH-64.

Distribution of Accidents with Respect to Altitude and Airspeed. Figure 6 depicts the altitude and airspeed at time of emergency for each of the AH-1 accidents resulting in occupant injury. Those accidents in which in-flight escape was

judged of some potential benefit generally fall into a region where airspeed (at time of emergency) is greater than 50-60 knots. Some benefits of in-flight escape are also projected for a lower airspeed, high altitude regime. The plot also shows that a low altitude and low speed (less than 50 knots) region has accidents in which in-flight escape is least likely to be of any benefit. Review of the data shown in figure 6 shows that although some accidents occurred well within the zero-zero escape envelope of Appendix A, the in-flight escape system was not considered effective. This is due to the fact that escape is a function of a number of parameters (see figure 2) and not only of the speed and altitude. In each of the accidents within this low airspeed and low altitude region, these other parameters (e.g., time for crew to make decision to eject) eliminated any benefits of in-flight escape.

Crashworthiness and In-flight Escape System's Effects on Injuries. Figure 7 is the plot of all fatal and nonfatal injuries which were judged to be avoided as a result of increased crashworthiness in the YAH-64.³ The graph also depicts all injuries and fatalities judged to be avoided due to in-flight escape. In plotting these, only in-flight emergencies that had a probability of a successful in-flight escape of .5 or better were counted.

The effects of in-flight escape and crashworthiness appear to be independent. In all cases in which fatalities were prevented by the in-flight escape system, crashworthiness improvements were not a factor. The converse was also found to be true.

The fatalities which were avoided as a result of crashworthiness fall in the higher speed region and occur in those emergencies in which in-flight escape probability was less than .5. The in-flight emergencies in which in-flight escape was of benefit are of somewhat lesser speed and higher altitude.

Analysis of the nonfatal injuries shows that there are some in-flight emergencies which appear to benefit from in-flight escape and crashworthiness. Out of 21 emergencies in which crashworthiness was a positive factor in injury avoidance, six cases also were effected by in-flight escape. In these cases, the benefit of in-flight escape is eliminated by increased crashworthiness in the YAH-64.

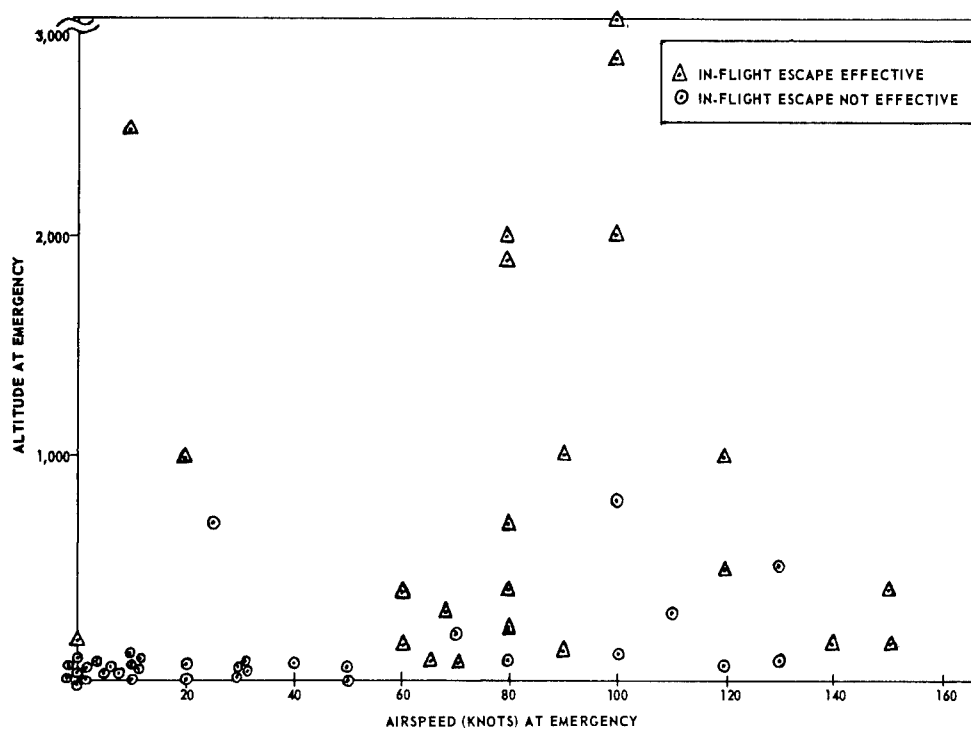


FIGURE 6.—Distribution of all AH-1 Accidents Resulting in Injury by Altitude and Airspeed

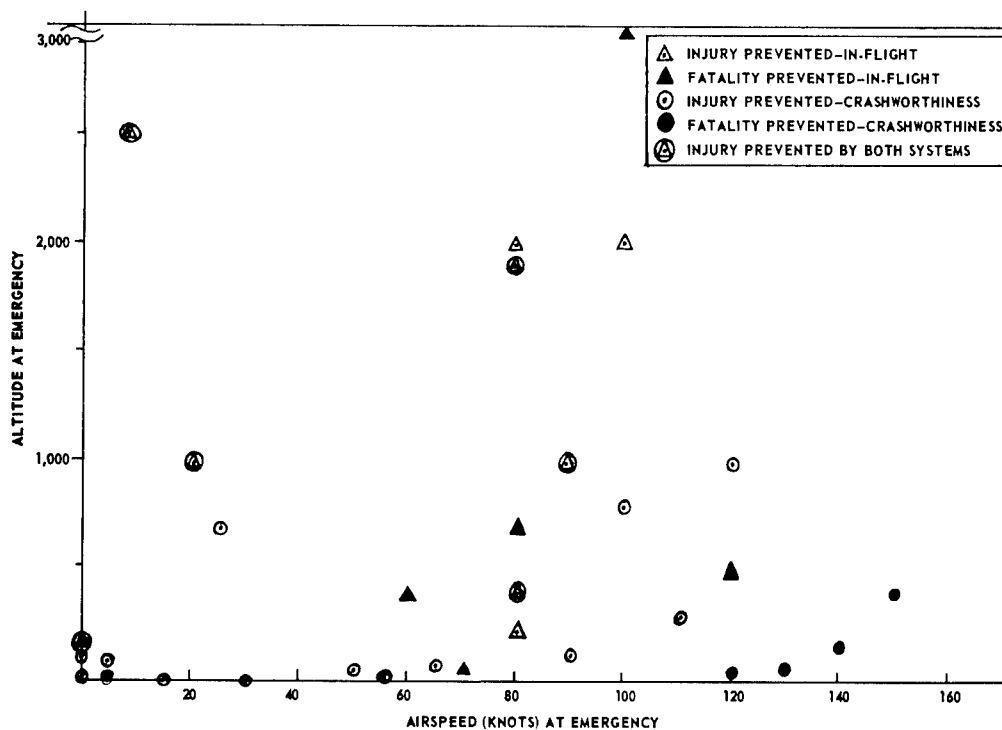


FIGURE 7.—Distribution of Injury/Fatality Prevention: In-Flight Escape vs. Crashworthiness

CONCLUSIONS

Study of AH-1 in-flight emergencies and of the proposed Required Operational Capability for an in-flight escape system provides the following conclusions:

- Reasonable projections for the economic benefits (in aircraft accidents) of in-flight escape systems in attack helicopters are as shown in the tables and graphs in this report.

- The benefits of in-flight escape are complementary to the benefits of crashworthiness in that YAH-64 crashworthiness and in-flight escape generally would benefit different emergency situations.

- There is a low altitude vs. low airspeed regime in which in-flight escape is of minimal or no benefit in reducing injuries due to aircraft

accidents.

- The estimated economic benefits of in-flight escape are about twice as great in the AH-1 as in the YAH-64 due largely to the projected lower accident rate of the YAH-64.

- Other benefits of in-flight escape (beyond pure economics of accidents) have to be considered in any evaluation of its effectiveness.

RECOMMENDATIONS

- That the results of this study be used in conjunction with other potential benefits in cost and operational effectiveness studies of the proposed in-flight escape system.

- That the results of this study be used to develop the performance requirements for any in-flight system developed for attack helicopters.

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APPENDIX A
PROPOSED REQUIRED OPERATIONAL CAPABILITY (ROC)

HELICOPTER IN-FLIGHT ESCAPE SYSTEM (PERSONNEL) FOR ATTACK HELICOPTERS

1. **Statement of Need.** An in-flight escape system for crew personnel of the AH-1() and AH-64(AAH) attack helicopter is needed to enhance crew safety/survivability from in-flight emergencies which result in uncontrolled flight, and which the danger of loss of lives to crewmember is inevitable. There is presently no practical means of in-flight crew escape from the attack helicopter. This system will provide survivable escape (extraction) for crewmembers throughout the flight envelope of the attack helicopters. CARDS Priority I (Safety), Recommended CARDS paragraph; to be provided by HQ, USATRADO. Engineering Development of this system is planned under project 6:42; No. IF264209DC5202. Material Developer: HQ, DARCOM (HQ, AVSCOM).

2. **Time Frame:** FY 1979-1981

3. **Operational Deficiency.** Combat (SEA) and accident fatality data of the AH-1() helicopter indicates that fatalities have occurred which were potentially survivable with an in-flight escape system. The autorotative procedure is satisfactory for some in-flight emergencies, which may terminate in controlled flight conditions, but will not suffice when applied against in-flight emergencies such as flight control malfunctions, main rotor loss, tail rotor loss, midair collision, fire/explosion, aviator incapacitation and destruction of engine/flight components and systems by energy infrared (IR) missile systems. Additionally, autorotative procedures are not conducive to crew survival during in-flight emergencies (controlled) which occur over unfavorable terrain, i.e., mountains, water, etc., or during NOE operations, where sufficient altitude is not available for autorotation. Current ground and air to air threats by potential enemy forces possess a threat to the attack helicopter crew that can only be solved by an in-flight escape system.

4. **Operational Concept.**

a. The system will be installed on the

AH-1() and the AH-64 attack helicopters. Climatic conditions shall not restrict the system's operational capability. This system shall serve as a means for insuring crew survivability on attack helicopters. The system will be used by the crew to counter in-flight emergencies which result in uncontrolled flight. This system shall be employed in lieu of autorotation procedures, under in-flight emergency conditions which include, but are not limited to: flight control malfunctions, main rotor loss, tail rotor loss, midair collisions, fire/explosions, aviator incapacitation, damage to aircraft propulsion/flight control systems, such as strikes by infrared (IR) seeking missiles. This system will also be used where in-flight loss of power conditions occur over terrain unsuitable for autorotative procedures, such as mountains and water. System activation may be accomplished by either crewmember, throughout the flight envelope of the attack helicopters. The airspeed envelope through which the system shall operate is defined as 0 to 250 knots airspeed, and 0 to 20,000 feet ASL altitude. An escape sequence could typically consist of main rotor system severance, crew-canopy opening/jettison and crew extraction by means of power tractor rocket/parachute systems. Operation of the escape system shall not cause degradation of the crewmember's ability to undertake surface survival/enemy evasion measures.

b. The system employed will be integrated as a subsystem of the AH-1()/AH-64 attack helicopters. Quantity required shall be on the basis of one complete system per each attack helicopter (pilot/gunner).

5. **Essential Characteristics.**

a. **Minimum Essential Characteristics.** The in-flight escape system must be effective, reliable, and function satisfactorily at aircraft critical altitude, speed, aircraft altitude, roll, yaw, pitch rates as defined in table 1.

TABLE 1.—Critical Performance
AIRCRAFT CONDITION AT ESCAPE SYSTEM INITIATION

Terrain Clearance Altitude (Feet)	Attitude	Sink Rate (fpm)	Speed (Kts)	Roll Rate (°/Sec)	Pitch Rate (°/Sec)	Yaw Rate (°/Sec)
0	Wings and nose level	0	0	0	0	0
0	Wings and nose level	0	150	0	0	0
150	Wings and nose level	3000	80	0	0	0
0	Wings level and 20° nose down	0	50	0	0	0
75	30° bank and nose level	1500	150	0	0	0
100	45° bank and nose level	1500	150	0	0	0
100	90° bank and nose level	0	150	0	0	0
150	90° bank and nose level	1500	150	0	0	0
200	180° bank and nose level	0	0	0	0	0
200	180° bank and nose level	0	200	0	0	0
200	180° bank and nose level	0	200	+200	65	90
200	180° bank and nose level	0	200	-60	65	90
50	Wings level and 5° nose down	1000	150	0	0	0
75	Wings level and 10° nose down	1500	150	0	0	0
150	Wings level and 15° nose down	3000	150	0	0	0
250	Wings level and 30° nose down	5000	150	0	0	0

The system will enhance crew survivability from in-flight emergencies, such as loss of control conditions throughout the most critical helicopter altitude anticipated. A zero-zero (altitude/air-speed) capability is essential. The system must provide a satisfactory alternative to autorotative procedures for correcting in-flight emergencies which result in uncontrolled flight and will be optimized for low-level flight profiles. The condition refers to, but is not limited to, one main or tail rotor loss, midair collisions, flight control malfunctions, fire/explosions, aircrew incapacitation, and damage to aircraft propulsion on flight control systems as a result of every action, such as strikes by informed IR missiles. The system must be capable of successfully operating in climatic zones 1 through 8 as defined in AR 70-38 and shall not significantly affect the reliability, availability, and maintainability requirements of the attack helicopter.

b. Component Design. An automatic sensing system will ensure that the disabled aircraft and escaping crewmen are in compatible altitudes for a safe extraction (escape) sequence. This component will be required to ensure safe extraction/escape during critical altitude/attitude pitch and roll rate conditions as noted in table 1.

c. Compatibility Requirements. The complete escape system installed weight will not exceed 80 to 100 pounds and must be compatible with standard and developmental subsystems, components, and associated equipment of the AH-1() and AH-64() attack helicopters. This includes armament/fire control, cockpit/crew station geometry, and life support equipment, i.e., body armor, survival vests, restraint systems, survival radios, canopy removal systems.

d. System-Subsystem Design. The design of the escape (extraction) system shall include the following subsystems as applicable to the specific attack helicopters in which the system is to be utilized:

(1) Escape initiation and sequencing (ballistic).

(2) Main Rotor Severance System: This component of the system shall be designed to jettison the main rotor system, in a predetermined deviation by ballistic components, to minimize any potential danger of impinging on adjacent helicopters or the escaping crew. The sequencing of the main rotor severance system shall be determined by the specific attack helicopter (AH-1()/AH-64()).

(3) Tail rotor neutralization.

- (4) Cockpit/canopy severance and jettison.
- (5) Rocket extraction and parachute recovery system.

e. Subsystem Design Features. The following features shall be included in subsystem design:

(1) Escape Initiation: The system shall incorporate one firing control activation device per crewman station. Completely automatic functioning of all components of the system will occur after activation of the firing control handle. A discrete and positive means of initiating the escape system from that of the canopy removal system (CRS). It is mandatory that either system be separate and distinct with no possibility of inadvertent initiation of unintended systems. A completely self-contained energy system is required.

(2) Operational Safety: It must be possible to visually inspect the system(s) continuity for any activation of component(s) which, if inoperative or improperly installed, would cause the system to possibly fail. The escape (extraction) system(s) shall be designed to preclude/prevent inadvertent activation by any internal or external source, i.e., gunfire, fire, radio/ECM signals, etc., other than as intended.

(3) Ballistic Components and Ground Safety Equipment: Ballistic components used in severance of aircraft components during the escape system's operation shall function in such a way as to minimize fragmentation. A removable ground safety pin for each crew station equipped with an escape (extraction) system shall be provided and pin installed to preclude inadvertent activation by ground crew personnel.

f. Technical Performance Characteristics:

(1) Redundancy. Redundancy shall be incorporated in the transmission of the firing stimulus to all ballistic devices. A completely self-contained energy system shall be utilized which demonstrates redundancy in maximum separation of energy transfer between the firing control and all ballistic components that comprise the escape system.

(2) Reliability. Having once been initiated, the probability that the escape system can complete its entire sequence without a failure shall be no less than .90. (A failure is defined as follows: any malfunction that causes or may cause incomplete operation or serious personnel

safety hazards.)

(3) Maintainability. The escape system shall be designed to be essentially maintenance-free and require nothing other than routine inspections for mechanical damage. Provision for replacement of average ballistic components safety shall also be included. Adequate warning placards, both inside and on the extension of the aircraft, shall be provided.

g. Human Factors Engineering.

(1) Human engineering/human factors. The escape system design shall consider and apply the criteria on human engineering as defined in MIL-H-46855, MIL-STD-1472, MIL-STD-250C, and MIL-STD-1333. AFSC DH-1-3 shall also be utilized as a guide.

(2) Field of vision. The escape system shall be designed and installed in a manner that will not degrade crewmembers' fields of vision. The effect of the system and its components shall be depicted upon field of vision plots in accordance with the requirements established by MIL-STD-850.

(3) Impulse noise levels. The impulse noise levels associated with the operation of the escape system, and measured at the ears of a 50th percentile aircrewman seated with his eyes on the design eye position in each aircrew station, shall not exceed a level which could cause permanent auditory damage or impairment of the aircrewman while wearing normal protective devices in accordance with TB MED 251.

(4) Toxicology. The system will be designed to minimize any possible health hazard to the aircrewmember from the resultant chemical reaction of system activation.

(5) Human factors general design requirements. Shall be in accordance with MIL-STD-1472 and the following:

(a) Crewmember accommodations. The system shall accommodate at least the 3rd through 98th percentile crewman, wearing applicable personnel protective equipment and shall provide a comfortable condition in which the efficiency and effectiveness of the aircrewmembers are optimized. The crewmember must be able to escape without intentionally assuming a position other than his normal operating position.

(b) Cockpit compatibility. The design of the system shall be compatible with the aircrew station geometry in which the system shall be

installed. Location of the escape system and components shall permit ready entry into and egress from the seat by crewmembers. The location shall not hinder emergency ground egress from the helicopter. Extraction shall not cause crewmembers striking or being struck by the windshield, canopy, armament sighting devices, or other cockpit components during operation of the escape system. Cockpit compatibility shall be in accordance with specifications set forth in MIL-STD-250C and MIL-STD-1333.

(c) Vulnerability characteristics. The system shall not be impaired with or subjected to the following hazards:

1. 7.62mm API projectile or comparable shrapnel at 0° obliquity and 100 meters.

2. EW vulnerability. Provisions must be made to prevent inadvertent activation of the system by internal or external electromagnetic energy. This energy would be spurious radiation from the aircraft systems, directed energy from ground sources, or any atmospheric electrical energy.

3. Nuclear vulnerability. Nuclear hardening not required.

4. Countersurveillance characteristics. The standard multicolor configuration shall be

used for the parachute canopy.

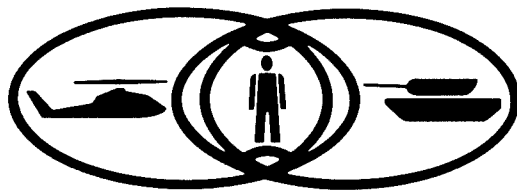
6. **Technical Assessment.** The proposed in-flight escape system is an engineering development effort requiring adaptation of proven extraction concepts previously developed for U.S. Air Force/U.S. Navy escape systems. This effort applies to the U.S. Army AH-1() and AH-64 attack type helicopters. Developmental effort is required for rotor blade/mast severance and canopy opening sequencing. Incorporation and modification of current, proven "extraction escape systems" currently in use in USN/USAF fixed wing aircraft will be required. The extraction of the aircrewmembers and subsequent parachute recovery will require modification of existing systems so as to conform to space and weight limitations. It is technically feasible to develop and qualify an in-flight escape system for the current series of attack helicopters. The movement and application of the proposed in-flight escape system will have an impact on logistical supportability in terms of funds, transportation, and manpower. To minimize this impact, concurrent application of this system with other product improvements and engineering development efforts is desired.

**APPENDIX B
IN-FLIGHT ESCAPE ANALYSIS WORKSHEET**

Review _____

MISSION	FLIGHT MODE	EMERGENCY CONDITION	LOCATION	ALTITUDE	AIRSPEED	ATTITUDE		
						PITCH	ROLL	YAW

FACTOR	PARACHUTE	YANKEE	CAPSULAR	EJECTION
Crew Condition				
Decision Time Available				
Crew Decision to Eject				
System Mechanical Reliability				
Within Envelope of In-Flight Escape System				
Probability of No Injury During Escape Sequence				
Probability of Injury Reduction				
Casualties Prevented				



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